2025

AP® Physics 2: Algebra-Based

Sample Student Responses and Scoring Commentary

Inside:

Free-Response Question 4

- ☑ **Scoring Guidelines**
- ☑ **Student Samples**
- ☑ **Scoring Commentary**

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Question 4: Qualitative Quantitative Translation (QQT) — 8 points

A

For indicating **one** of the following: **Point A1**

- The claim is correct if a justification is not provided.
- An indication about the claim that is consistent with the justification provided.

For a correct comparison of **one** of the following: **Point A2**

- The wavelength of violet light is shorter than the wavelength of red light.
- The frequency of violet light is greater than the frequency of red light.

For indicating that a shorter wavelength corresponds to a shorter path length difference, resulting in a shorter distance between the center of Band A and the center of the central bright band **Point A3**

Example Response

The claim is correct. The wavelength of violet light is shorter than that of red light. This shorter wavelength leads to a shorter path length difference for violet light as compared to red light. This corresponds to a shorter distance between Band A and the central band.

B

For a multistep derivation that includes $d\left(\frac{y_{\max}}{L}\right) \approx m\lambda$, $d\sin\theta = m\lambda$, $\Delta D = m\lambda$, $\Delta D = d\sin\theta$, $\Delta D \approx d\left(\frac{y_{\max}}{L}\right)$, $d\sin\theta \approx d\left(\frac{y_{\max}}{L}\right)$, $\sin\theta \approx \left(\frac{y_{\max}}{L}\right)$, $\tan\theta \approx \left(\frac{y_{\max}}{L}\right)$, $\theta \approx \left(\frac{y_{\max}}{L}\right)$, an equation that is equivalent to one of the equations listed, or a relevant equation **Point B1**

For a substitution of $\frac{c}{f}$ for λ **Point B2**

For correctly relating $y_{\max}$ to the orders of bands A and B **Point B3**

(e.g., $2\left(y_{\max,2} - y_{\max,0}\right) = 2\left(\frac{(2)cL}{fd}\right)$)

Scoring Note: A correct, isolated, final expression earns points B2 and B3.

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Example Response

$$d\left(\frac{y_{\max}}{L}\right) \approx m\lambda$$

$$\lambda = \frac{c}{f}$$

$$d\left(\frac{y_{\max}}{L}\right) = m\frac{c}{f}$$

$$y_{\max} = \frac{mcL}{fd}$$

$$\Delta y = 2\left(y_{\max,\,2} - y_{\max,\,0}\right)$$

$$\Delta y = 2\left(\frac{(2)cL}{fd}\right)$$

$$\Delta y = \frac{4cL}{fd}$$

C	For correctly indicating that the expression derived in part B is or is not consistent with the answer provided in part A	**Point C1**
	For a justification that includes the consistent functional dependence between the spacing between bright bands on the screen and the frequency or wavelength of light	**Point C2**

Example Response

My derivation in part B is consistent with my answer in part A. Violet light has a greater frequency than red light. Because $\Delta y = \frac{4cL}{fd}$*, a greater frequency for violet light results in a shorter distance between bright bands.*

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Question 4

PART A

The student's claim is correct. This is because violet light has a much smaller wavelength than red light, meaning that violet light will have a smaller path length than red light and therefore have a shorter distance for the light to travel from the slits to the center of Band A, therefore having a smaller distance between the center of Band A and the center of the central bright band.

PART B

$d\left(\frac{y_{max}}{L}\right) \approx m\lambda$ (m_1) $\lambda = \frac{c}{f}$ (c = speed of light) $d\left(\frac{y_{max}}{L}\right) = \frac{c}{f}$

y_{max} = distance between central band and band A

$2y_{max}$ = distance between band A and band B

$y_{max} = \frac{cL}{fd}$

$2y_{max} = \frac{2cL}{fd}$

Question 4 is continued on the next page.

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Question 4

PART C

Yes, my expression is consistent with my answer because my answer in part A states that the distance between bands decreases as wavelength decreases. Since $\lambda \propto \frac{1}{f}$, the distance between bands would decrease as frequency increases, which is consistent with my equation that shows: $2y_{max} = \frac{2cL}{fd}$, where $y_{max} \propto \frac{1}{f}$, consistent with my answer from part A.

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Question 4

PART A No, the student is not correct. We can see from $d\left(\frac{y_{max}}{L}\right) \approx m\lambda$, then when we only change the wavelength about the light then the distance between bands also has to change. Since violet has a much smaller wavelength than red then the path of the light travelled to get to its band A is much smaller than red lights path

PART B

$$d\left(\frac{y_{max}}{L}\right) \approx m\lambda$$

$$\downarrow$$

$$d\left(\frac{y_{max}}{L}\right) \approx m\frac{v}{f} \leftarrow \text{speed of light } (c)$$

$\frac{dx}{L} = \frac{mc}{f}$ ← distance between band levels (y between A and B)

$\frac{dy}{L} = \frac{4c}{f}$ → get y by itself → $\boxed{\frac{4Lc}{fd} = y}$

Question 4 is continued on the next page.

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Question 4

PART C This is consistent with my answer with part A because as you go down the rainbow, red to violet, frequencies get bigger. Since f is in the denominator in my equation then the bigger it gets the smaller y, the distance from Band A to Band B, gets which coincides with my answer to A where I said that violet would produce smaller distances to bands than red. These answers are also connected because f is in the denominator for both the derived equation and in the wavelength formula ($\lambda = \frac{v}{f}$).

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Question 4

PART A

Correct, because the λ of a violet laser is smaller than the λ of a red laser

PART B

$\Delta D = d \sin\theta$

Question 4 is continued on the next page.

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Question 4

PART C

NO, because in order to use $s\theta = d\sin\theta$, θ has to be $\theta < 10^\circ$

Question 4

Note: Student samples are quoted verbatim and may contain spelling and grammatical errors.

Overview

NEW for 2025: The question overviews can be found in the *Chief Reader Report on Student Responses* on AP Central.

Sample: 4A
Score: 7

Part A earned all three points. The first point (A1) was earned because the response indicates that the student's claim is correct. The second point (A2) was earned because the response indicates that the wavelength of violet light is shorter than the wavelength of red light. The third point (A3) was earned because the response indicates that the path length for violet light is shorter because the wavelength of violet light is shorter than that for red light.

Part B earned two out of three points. The first point (B1) was earned because the response indicates a multistep derivation that includes a relevant equation. The second point (B2) was earned because the response correctly substitutes a correct expression for wavelength. The third point (B3) was not earned because the response does not correctly account for the distance between Band A and Band B.

Part C earned both points. The first point (C1) was earned because the response indicates that the expression derived in part B is consistent with the answer in part A. The second point (C2) was earned because the response indicates consistent functional dependence; as the frequency increases, the distance will decrease.

Sample: 4B
Score: 6

Part A earned two out of three points. The first point (A1) was not earned because the response indicates that the student's claim is not correct, and the justification is not consistent with the indication that the claim is not correct. The second point (A2) was earned because the response indicates that violet light has a greater frequency than red light. The third point (A3) was earned because the response indicates that the violet light traveled a shorter path length to the screen.

Part B earned all three points. The first point (B1) was earned because the response indicates a multistep derivation that includes a relevant equation. The second point (B2) was earned because the response correctly substitutes a correct expression for wavelength. The third point (B3) was earned because the response correctly indicates that m is equal to 4, which is equivalent to a second order of m equals 2 that is then doubled.

Part C earned one out of two points. The first point (C1) was not earned because the response indicates that the expression in part B is consistent with the answer in part A. However, the expression in part B is not consistent with the answer in part A. The second point (C2) was earned because the response indicates consistent functional dependence; as the frequency increases, the distance will decrease.

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Question 4 (continued)

Sample: 4C
Score: 2

Part A earned two out of three points. The first point (A1) was earned because the response indicates that the student's claim is correct. The second point (A2) was earned because the response indicates that the wavelength of violet light from a laser is shorter than the wavelength of red light from a laser. The third point (A3) was not earned because the response does not indicate an appropriate reference to path length difference.

Part B did not earn any of the three points. The first point (B1) was not earned because the response begins with a relevant equation, but the response does not include a multistep derivation. The second point (B2) was not earned because the response does not substitute an expression for wavelength. The third point (B3) was not earned because the response does not relate y_{max} to the orders of bands.

Part C did not earn either point. The first point (C1) was not earned because the response in part B is not consistent with the response in part A. The second point (C2) was not earned because the response does not address functional dependence.

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